NTUMUN 2021

STUDY GUIDE

UNCOPUOS

Table of Contents

Chair Introductions

Huspidiatul Anwar Gemadiyah – Head Chair

Email: huspianwar@gmail.com

Distinguished delegates,

Huspi is a final-year undergraduate student of International Relations from Brawijaya University, Indonesia. He'd like to welcome you to NTU MUN 2021, despite of it will be held online, he hopes that all of the delegates and parties involved will gain a significant benefit, especially for their self-development in regards of delivering their argument, substantial knowledge, problem-solving skill, as well as the proper knowledge to fathom an international issue. As he is currently doing his thesis, he hopes that by communicating and engaging with all of the delegates, could become another escape for him from this grueling final-year challenge as a college student. Nonetheless, he is a chill person that will happily welcome everyone to chat or contact him. Lastly, he wishes you all the best and good luck not only for your conference, but also your future endeavors. To contact him, please reach him through: huspianwar@gmail.com

David Le - Assistant Chair

Email: anhlq28102002@gmail.com

Dear talented delegates,

David is an 18-year-old student at a university in Vietnam. It is his pleasure to serve as your chair at the United Nations Committee on the United Nations Peaceful Uses of Outer Space at Nanyang Technology University Model United Nations 2021.

He can't wait to see his delegates in March as well as to witness their excellent negotiation skills. Hopefully, joining NTUMUN 2021 not only helps them in making more new friends but also learning new valuable skills that benefit their self-improvement. Hope that all of them can learn more in this journey. Do remember that he is always ready to help his delegates if they need. All they need is just sending him an email to the email address attached above.

Now, it's time for liftoff. The floor is now open, are you ready to speak?

Good luck and can't wait to see you there!

Komal Mekala - Assistant Chair

Email: komalmekala99@gmail.com

Komal Mekala is a 21-year-old undergrad studying engineering at VIT, Pune in India. A person with a plethora of talents and with five hefty years of experience in the MUN circuit, Komal's name remains unmatched.

Komal is a strong-willed person and can be very persuasive in her approach. Her passion and commitment towards her work are worth taking lessons from. She is famed for her relentless dedication and her strong work ethic is evident from the way she does tiny things.

You will find her charm and friendly attitude extremely approachable and when you're in any kind of difficulty, Komal is the one you can always rely on.

She hopes to host you all with all of her enthusiasm and make it a worthwhile experience for everyone! Good luck!

Jason Ong Han Meng – Assistant Chair

A recent graduate of the NUS High School of Mathematics and Science, Jason sometimes wonders how he got into MUN in the first place. Up until this point, he still doesn't have the answer, but hopes that his scholarship will extend to NUS so that he can continue this journey. Having previously attended 26 conferences in Malaysia, Singapore and Indonesia, with more than half of them as a staff member, NTUMUN 2021 marks Jason's first conference before his term in university begins. He looks forward to meeting his delegates at the conference and hopes that they will bring with them great tea, and greater debate.

Welcome Letter

Dear distinguished delegates of NTUMUN'21 UNCOPUOS.

First of all, we would like to congratulate you on your hard work for becoming a delegate of NTUMUN'21 UNCOPUOS this year. We reassure you that you have made the right choice to become a delegate of this committee. All of us are looking forward to meeting you and hearing your ideas for solving diplomatic disputes.

As being set as an intermediate committee, the topics for UNCOPUOS this year are (1) Militarisation in space and (2) Space debris and waste disposal. These topics may seem rather unfamiliar and problematic to some of the delegates here but we hope that you can get used to it soon and work on it and deliver some good policies or solutions.

At UNCOPUOS, we hope that each delegate will amaze us with their innovative resolutions and speeches regarding the problem. Also, we want to see your confidence and readiness to speak up. With those things in mind, nothing could stop you from raising your placard to speak.

Please note that the position papers are due before the conference. We advise you to start on it as soon as possible and consult academic resources to strengthen your arguments. If you have any further questions as long as they are about the committee or the topics, feel free to email us.

We are looking forward to seeing you at the conference and wish you the very best in your preparations.

Sincerely,

Chairs of UNCOPUOS.

Introduction to Council

Under the General Assembly Resolution 1348 (XIII) on the agenda of "Question of the peaceful use of outer space", the UN established the Committee on the Peaceful Uses of Outer Space in 1958 as a specialized *ad hoc* committee to monitor the usage of outer space by the member states [1]. Consisting of 18 members at that time, this *ad hoc* committee served to report to the GA with regards to its activities and resources involving the UN, specialized agencies, as well as other international bodies relating to peaceful uses of outer space [2]. It also ensures international cooperation within the framework of the UN and facilitates discussion among the member states should any legal problems arise regarding the exploration of outer space [3].

In 1959, one year after its establishment as an *ad hoc* committee, the GA then made COPUOS into a permanent body under the UN itself [4], functioning as a focal point of international cooperation of governments, governmental and non-governmental organizations [5] for the exchange and dissemination of information related to space exploration solely for economic and scientific purposes. For its function, UNCOPUOS has 2 sub-committees under it: The Scientific and Technical Subcommittee and the Legal Subcommittee [6]. The former tackles the more technical challenges in space and works on the technological development relating to outer space uses as well as developing cooperation with other national research institutions [7], while the latter monitors the implementation of space law treaties consisting of the 5 treaties & 5 principles.

In accordance with the topic, it is important to note what kind of parameters, additional principles, standards, norms, qualifications, or even classifications that could be set by this committee to determine to what extent a

certain thing could be used or developed relating to the peaceful uses and exploration of outer space.

TOPIC 1 - Militarisation of Space

Summary

The Cold War is noted as the first international conflict where the conflict of power between states was not limited solely to the Earth. Great advancements in technology and space programmes developed by leading countries have shown what mankind could achieve in outer space. This rapid advancement into a previously unknown frontier has made the international community as a whole concerned about their power or national security, as the capability to utilize outer space might become an additional indicator of a country's power and may have a significant impact on their countries' national security. For instance, besides the satellites that have specific civilian purposes for communication, weather forecasting, remote sensing, and others, there are still many satellites or other outer space objects that serve either mixed-purposes or military purposes for reconnaissance, espionage, or even for the control/guidance of an ICBM (Inter-Continental Ballistic Missile) to be launched from earth towards another area on earth.

With the aim of preventing such perilous contestation from many major powers countries, the Outer Space Treaty and its follow up treaties were drafted, where it was emphasized that outer space is not subject to claims of sovereignty from any states, yet, still free for all of states to explore for peaceful purposes such as economic and scientific purposes. The state is also responsible for any kind of damage caused by their space objects as well as all of the space programmes conducted by the government or non-state actors (that is based on their country)[8]. It also prohibits the use or installation of nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner[9].

Although Weapons of Mass Destruction have been explicitly prohibited under the Space Law Treaties, these treaties have not addressed the various forms of weaponry and military technology developed since their ratification. The treaties have also failed to address weaponry which might pose potential threats towards other countries that have yet to be developed in the future. The term "space weapon" should also be scrutinized by the delegate; whether it is limited to exerting destructive capability towards an outer space object or towards entities on Earth, and whether its classifications extend to Earth-bound weapons that can affect objects in outer space. Thus, having a clear definition of militarisation and weaponization first is key towards identifying what the relevant member states may be doing in regard to their space programme. Further limitation may or may not be needed by the international community. However, from a realist perspective in international relations, it should be clear that a lack of clear boundaries and definitions could cause a security dilemma or another form of arms race, should a member state have the capability to threaten other countries' operations in outer space.

Introduction

The contestation of power has no boundaries; as long as the state has the capability, its economic, military, technology, and intelligence operations can be developed as much as they want in accordance with their interests. This contestation of power, previously occurring as part of states' geopolitical and power projection towards another region, has recently expanded into the new frontier of outer space. With a rapid advancement on technology, satellites, space stations, and other space programmes were developed, and were then utilised by state and non-state actors to serve both civilian and military purposes.

The UN Outer Space Treaty (OST) in 1967 perhaps still the most relevant piece of legislation for analyzing state and non-state entity activity in outer space. Ratified by more than 100 countries, including nations with major space programs like the United States, Russia, and China, the treaty is designed to prevent both the militarization of space and national appropriation of celestial bodies at the height of Cold War tensions. Moreover, the treaty is widely accepted as an authoritative document and has formed the basis for all other space treaties that have succeeded [10].

Given the vast opportunities in outer space available to those with the capability to utilize it, as with the Arctic as a continent full of potential, the international community has felt the moral obligation to regulate its usage in order to prevent a singular state from asserting too much power over it. Since then, 5 fundamental Treaties and 5 Principles related to outer space have shown international commitment towards limiting expansionism into outer space. It is now left to the international community and international organizations such as UNCOPUOS to ensure the outer space should be fairly used by all states in accordance with international laws and principles. Nonetheless, due to international

laws being “soft laws” due to their non-legally binding nature (concerning resolutions passed by bodies other than the UN Security Council), it is hence difficult to guarantee the compliance of each Member State towards the international regime.

Background

History

The launching of Sputnik 1, the first artificial Earth satellite, in the midst of the Cold War in 1957 is considered to be a major milestone in the race for the exploration of outer space. This event sparked the process of a space race between the two superpowers of that time, the United States and the Union of Soviet Socialist Republics (USSR), to display their international prowess and technological advances for the advancement of their political beliefs [11]. With such an advancement, many countries had considered the development as a means of showing their power projection towards their control over outer space.

Deeply concerned with the exploitation of outer space by a select few countries and the possibilities of conflict in the new frontier of space, the international community tried to emphasize the importance of a peaceful outer space for all nations’ uses with the establishment of the UNCOPUOS itself as an *ad hoc* committee. Under the auspices of the UN, international cooperation and/or programmes[12] could be conducted through UNCOPUOS as an intermediary and to avoid an extension of national rivalries between member states into outer space.

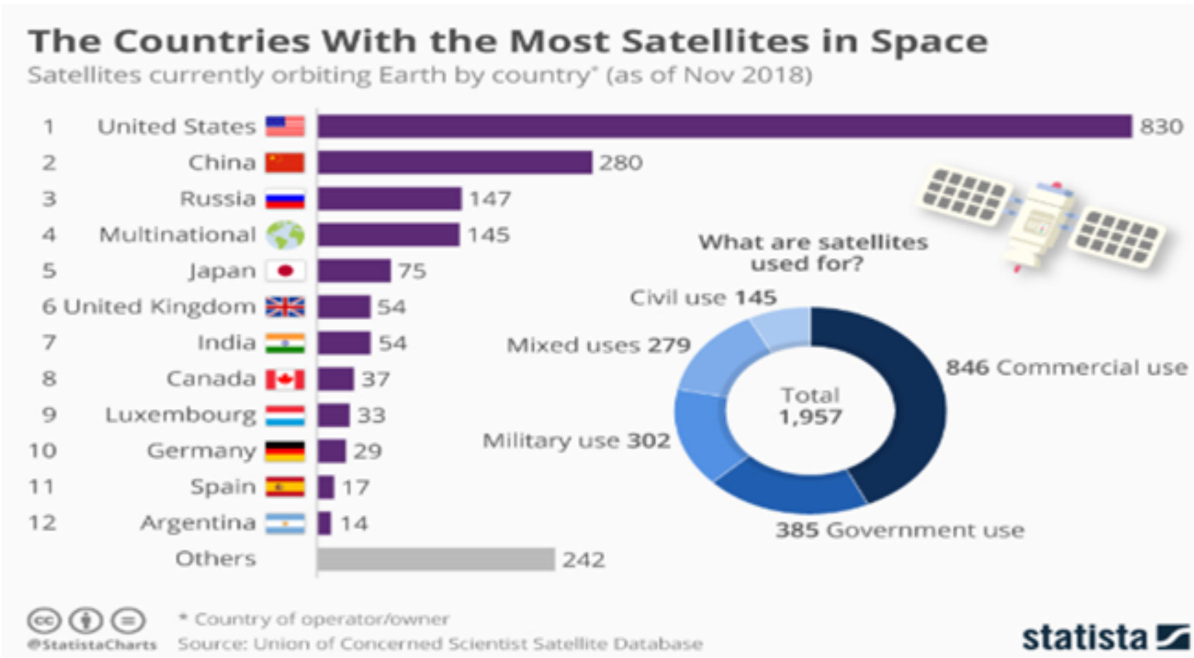
Documents and Perspective Analysis

A realist perspective in the international relations of a country involves an assessment of the capabilities of other countries to prevent security dilemmas. However, countries as political actors have a tendency to want to advance their

position and political interest, to project their international power over a certain area, or even the desire to expand their territory into another area. In doing so, countries often need to expand upon their military capabilities such that they are able to defend their national interest through means such as the placement of foreign military bases, enhancing the quantity and quality of their armed forces, technology, or weapons utilised. This process is often termed militarisation.

The writing of the 5 fundamental Treaties and 5 Principles related to outer space has become the expression of the international community's concern that the contestation of power is not limited solely to the Earth, and also serve as the key guidelines that outline the collective agreement of the international community's opinion towards the usage of outer space. Indeed, with the unlimited boundaries in the new frontier of outer space, there is a significant interest from countries to explore its unknown potential and utilise it to its fullest. The Outer Space Treaty had a special emphasis on the matters of a state's sovereignty in Outer Space, where it stated that "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[13] Moreover, the Outer Space Treaty included the prohibition on the usage of Weapons of Mass Destruction (WMD) in outer space, as well as the installation of such weapons in outer space via any celestial body, satellite, or other object that had been launched from earth. Lastly, the treaty also provided that "the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind."[14] These fundamentals of international cooperation regarding space outline that the usage of outer space is intended for peaceful purposes that benefit all countries without regarding existing boundaries on Earth.

Currently, there are more than 1,100 operational satellites in orbit around Earth, although it is estimated that about 3,600 satellites (out of the 6,600 that have been launched so far) remain in their orbit [15]. These satellites are used for a multitude of purposes, among them communications, navigation, weather, research, military surveillance, space stations and human spacecraft. Those functions of these satellites can be broadly classified into military and civilian purposes. However, practically any satellite could have a malevolent purpose due to the nature of "dual use" technologies—devices that can be deployed for both peaceful civilian and military purposes—. It needs to be taken into account as well that the treaty does not cover the possibility of inter-satellite attacks as well as cyberattacks, since cyberattacks disregard conventional boundaries of military power. Data exchange between satellites and Earth receivers can be hacked at multiple entry points. It is feasible for a satellite's control system to be co-opted by hackers, allowing them to disable its communications or even turn it into an ASAT (Anti-Satellite) Weapon [16].



Total satellites per country: Statisa

As shown by the picture above, a select few global superpowers contribute to a significant portion of satellites in space, yet we must be aware that unregistered satellites are a distinct possibility that needs to be considered by UNCOPUOS. Satellites by nature are difficult for international parties to keep track of once in orbit, with a majority of significant information regarding a satellite being held by the party responsible for its launch. Given the sensitivity of such information, transparency regarding satellite count and usage is lacking. With this emerging issue of unregistered satellites, these satellites could have technologies or systems that may disrupt other countries' satellites or disrupt public order in general. For instance, if an unregistered satellite collides with another countries' satellite that played an important function in nationwide telecommunication, it would be a major threat towards the affected country due to possible damages incurred without a

good idea of the cause. Thus, a proper monitoring process and registration process to enhance the transparency, accountability, as well as the liability of relevant parties and their satellites, are needed to be enhanced more for the stability of the international community on the uses of outer space.

Definitions

- **Militarisation**

Through the characteristics provided by Richard Tanter, it could be understood that a process of militarisation could be occurring if it exhibits at least one of the following five characteristics, inter alia:

a) an increase in the size, cost and coercive capacity of a nation's armed forces, police and security agencies.

b) a greater political role for the military.

c) an increase in the state's reliance on organized force, domestically and abroad, to secure its policy goals, rather than ideological hegemony and bargaining.

d) a change in the culture in the direction of values and beliefs that more effectively support organized state violence; and

e) increasing external offensive military alignment or alliance with other states, or use of force externally [17].

With the aforementioned characteristics, it could also be interpreted as an great political influence towards the military sector whereby it affects the increment of military power for the purpose of the policy-maker or its political

leader's goals in the (international) community. With a tremendous military power, once again, militarisation could serve as a potential threat towards others national security. Nonetheless, we cannot deny that it may become a "bargaining point" of such a country to increase their win-set in terms of negotiation within an international level negotiation. To add another perspective, Cynthia H. Enloe –a theorist who focuses on militarism– defines militarisation as follows:

> "Militarisation is a step-by-step process by which a person or a thing gradually comes to be controlled by the military or comes to depend for its well-being on militaristic ideas. The more militarisation transforms an individual or a society, the more that individual or society comes to imagine military needs and militaristic presumptions to be not only valuable but also normal."[18]

- **Weaponization**

According to Macmillan Dictionary, weaponization is defined as the act of making something ready to use as a weapon, the act of putting a weapon in a place, and the act of using something as a weapon, especially in politics. Additionally, in the context of weaponization in space, it can be understood as placement in orbit of space-based devices that have a destructive capacity[19].

- **Kinetic Energy Weapon**

Kinetic energy weapons (KEW) utilize the energy of a moving projectile, such as a bullet or rocket, in order to inflict damage on their target[20]. Projectiles from KEWs move at hypersonic velocities and convert over half of its mass into energy that could cause a huge impact towards the targeted object[21].

- **Direct Energy Weapon**

Direct energy weapons (DEW) are weapons or systems that possess the capability of producing a beam of concentrated electromagnetic energy or atomic particles that could be used to injure, kill, degrade, damage, or destroy its target [22].

- **Weapon of Mass Destruction**

A Weapon that could generate an enormous destructive impact and kill millions of people, jeopardize the natural environment whereas the impact would also affect the future generations [23].

- **Anti-Satellite (ASAT) Weapon**

An Anti-Satellite Weapon could be defined as a weapon in which it may be included as a ground-to-space, air-to-space, or space-to-space weapon that could destroy or incapacitate the satellite [24].

Scope of Debate

The Outer Space Treaty has become one of the fundamental legal bases of outer space usage ever since its adoption. Yet, it has not provided a specific identification or additional explanation with regards to the extent of militarisation afforded to member states of the international community, although the treaty does mention the prohibition of military installations, fortifications, or bases being established in outer space. Subsequently, military development in outer space is a matter of a member state's interpretation, although the treaty has already explained that the usage of military personnel in outer space is limited to scientific purposes, with the possibility of undisclosed interests.

Setting aside the militarisation of outer space with regards to the prohibition of weapons of mass destruction, including nuclear weapons, nations worldwide have come to rely on the development and usage of satellite technologies for military purposes. These include espionage and weapons testing, among others. In many cases, modern military technologies have an increasing level of integration with satellite functions, such as the Global Positioning System (GPS), satellite imaging for targeted drone strikes or intelligence gathering, as well as simple functions such as communication. As an increasing and tangible risk for the future of humankind, the international community has reaffirmed the importance of creating a robust framework dedicated to regulate and limit the militarisation of space and the use of the technology deployed in it. The rampant proliferation of unregistered satellites, military technology or weapons, should be a key issue discussed within the committee. Moreover, delegates should understand the committee's limitations before venturing on to how they could monitor and proceed with the registration process, classification of weapons of technology, as well as how to ensure the compliance of such member states.

Registration Process

The UN has attempted to regulate the registration process of any object that would be launched by states to outer space. The bedrock document lies within the Convention on Registration of Objects Launched into Outer Space or known as The Registration Convention. Cognizant of GA Resolution 1721 (XVI) Chapter B, Article 1, whenever Member States launch an object to the orbit or beyond, Member States are encouraged to furnish information promptly to the UNCOPUOS through the Secretary-General for the registration process of the object [25]. Within the Registration Convention, specifically on Article IV, it is requested for Member States to provide the following information, inter alia:

"(a) name of launching State or States.

(b) an appropriate designator of the space object or its registration number.

(c) date and territory or location of launch.

(d) basic orbital parameters, including:

(i) nodal period.

(ii) inclination.

(iii) apogee.

(iv) perigee.

(e) general function of the space object".[26]

As of January 2021, over 86% of all satellites, probes, landers, crewed spacecraft and space station flight elements launched into Earth orbit or beyond have been registered through the Secretary-General, according to UNOOSA (UN Office for Outer Space Affairs) [27]. However, both registered and unregistered space

objects should not be neglected by the international community. This is due to the duality that arises on the launching of space objects.

The dual use of space objects can be understood simply as the capability of the space object to have an additional function beside its initial general function which it was registered before. The interconnectivity of this issue with the main topic is that it has been the main obstacle in defining what a space weapon is and consequently emerging the establishment of preventive measures that would affirm a state's compliance if a treaty or agreement on a space weapons ban were to be established. Registration of satellites and their missions would also help to reduce suspicions directed towards particular states that were involved in the development of space weaponry. Hence, transparency and confidence-building measures (TCBMs) have been considered and proposed to increase trust and facilitate cooperation among countries on space issues [28].

Identification of weaponisation and militarisation process

Space has been "militarised", meaning it is used for military purposes. Still, it is not yet "weaponised," meaning that there are no weapons in outer space that can destroy other satellites or target the surface of the Earth. Though these attacks cannot be launched from space, the capacity to destroy satellites from the surface of the Earth has been proven and executed. The possibility of weaponisation in the space would threaten sustainable space exploration if weapons were to be deployed and utilised, destroying other space assets and generating space debris.

The term 'space weapons' includes weapons that are capable of targeting space assets located both in outer space and on Earth, as well as weapons which transit in outer space. Such weapons include satellites which can shoot lasers, or

rockets capable of launching satellites from the Earth into the Low-Earth Orbit (LEO). Russia, the US, France, China, Ukraine, India, and Japan have such capabilities, with Iran and North Korea not far behind. Henceforth, the process to identify weaponization conducted by states is very important to determine whether or not any weapons involved could result in tremendous collateral damage or could be considered as WMDs [29].

Key Stakeholders

Disarmament and International Security Committee (DISEC)

The First Committee of the United Nations, the DISEC, focuses on disarmament, global challenges, and threats to peace that affect the international community and seeks out solutions to the challenges in the international security regime. Moreover, the DISEC also works in close cooperation with the United Nations Disarmament Commission and the Geneva-based Conference on Disarmament [30]. During the Cold War, the UN General Assembly Special Session on Disarmament mandated that all negotiation for the monitoring process and negotiation process for the peaceful uses of outer space and its laws should be conducted through the Conference of Disarmament (CD) "in order to prevent an arms race in outer space" that are "held in accordance with the spirit of the Outer Space Treaty." [31]

Taking further action on the aforementioned matters, the CD then established an *ad hoc* committee on the prevention of an arms race in outer space (PAROS). This *ad hoc* committee was aimed at supporting the international community in identifying and examining issues relating to the legal protection of

satellites and confidence-building measures (CBM) among actors [32]. The PAROS mandate could be extended or expanded as long as there are proper recommendations towards the specific committee in which it should be negotiated later on. Nevertheless, states should take into account that PAROS, as an *ad hoc* committee, exists to support conflict resolution between state parties regarding weaponization or militarization by other sovereign states, given that it falls under its jurisdiction.

State Actors

The United States, Russia, China, Japan, Israel, and India are all investing in hit-to-kill systems to be utilised for anti-satellite (ASAT) purposes or missile defense. The significant ASAT capabilities of outer space powers are already well known. China had a high-profile incident of ASAT testing in 2007, when they launched a missile to destroy one of their obsolete weather satellites in LEO. China has also made significant development in Anti-Ballistic Missiles (ABM) which, like ASATs, could be utilised to target another country's surveillance, intelligence and reconnaissance satellites. The U.S. and Russia have successfully tested anti-satellite weaponry – in 2008, the U.S. took down a low-orbit defunct satellite and the Russians accomplished a flight test of the A-235 Nudol direct ascent anti-satellite missile. The Democratic People's Republic of Korea has recently joined the ranks of space-faring nations, launching their satellite into outer space. Iran is also improving their ASAT capabilities, according to a 2013 report that they are setting up a facility to track orbiting objects. Moreover, any advancements made into launching rockets to outer space are also inclined to the development of a nation's capacity of firing intercontinental and ballistic missiles.

Questions A Resolution Must Answer (QARMAs)

1. How can member states resolve the security dilemmas from the process of militarization?

2. Is the current international law such as the space law treaties still relevant with the current condition? If not, what kind of new framework, treaty, principle, or norm should be proposed?

3. How can UNCOPUOS ensure transparency as well as the compliance of the member states?

Endnotes

---

[1] United Nations General Assembly. 1958. *GA Resolution 1348 (XIII) : Question of The Peaceful Use of Outer Space.* United Nations. Retrieved from https://www.unoosa.org/pdf/gares/ARES_13_1348E.pdf

[2] Ibid. p.6

[3] United Nations Office for Outer Space Affairs. N.d. *COPUOS History*. United Nations. Retrieved from https://www.unoosa.org/oosa/en/ourwork/copuos/history.html

[4] United Nations General Assembly. 1959. *GA Resolution 1472 (XIV) : International Co-operation In The Peaceful Uses of Outer Space*. United Nations. Retrieved from https://www.unoosa.org/pdf/gares/ARES_14_1472E.pdf

[5] United Nations Office for Outer Space Affairs. N.d. Loc,cit.,

[6] ibid

[7] United Nations General Assembly. 1959. Loc,cit.

[8] UN Office for Outer Space Affairs. N.d. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*. United Nations. Retrieved from https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

[9] United Nations for Outer Space Affairs. N.d. Loc, cit.

[10] Hebert, K. (2014). Regulation of Space Weapons: Ensuring Stability and Continued Use of

Outer Space. Astropolitics, Vol. 12, No: 1, 1-26.

[11] Cornec, C. 2019. *The post-Cold War issues of the space conquest: Thoughts on the future of an increasingly attractive space*. University of California. Retrieved from https://escholarship.org/content/qt0kj1q52j/qt0kj1q52j.pdf?t=prfwji

[12] United Nations General Assembly. 1959. Loc,cit.

[13] United Nations General Assembly. 1967. *GA Resolution 2222 (XXI) : Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*. United Nations Office for Outer Space Affairs. Retrieved from https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html

[14] Ibid

[15] UCS Satellite Database. 2020. UCS Satellite Database. Retrieved from Union of Concerned Scientists https://www.ucsusa.org/resources/satellite-database

[16] Wood, J. 2019. *The Countries with The Most Satellites in Space*. World Economic Forum. Retrieved from https://www.weforum.org/agenda/2019/03/chart-of-the-day-the-countries-with-the-most-satellites-in-space/

[17] Tanter, R. 1984. *Trends in Asia*. Alternatives 10, no. 1 (January 1984): 161–91. https://doi.org/10.1177/030437548401000108.

[18] Enloe, C. 2000. *Maneuvers: The international politics of militarizing women's lives*. Berkeley: University of California Press.

[19] Reaching Critical Will (RCW). 2020. *Outer Space : Definition and Key Issues*. United Kingdom. Retrieved from https://www.reachingcriticalwill.org/resources/fact-sheets/critical-issues/5448-outerspace

[20] Nielsen, PE. 1994. *Effects of Directed Energy Weapon*. Library of Congress, USA. Retrieved from https://apps.dtic.mil/dtic/tr/fulltext/u2/a476195.pdf

[21] Sproull, DC. 2017. *Kinetic Energy Weapons : The Beginning of An Interagency Challenge.* InterAgency Journal Vol. 8, Issue 2. Retrieved from https://thesimonscenter.org/wp-content/uploads/2017/05/IAJ-8-2-2017-pg62-68.pdf

[22] Anna de Courcy Wheeler & Maya Brehm. 2017. *Directed Energy Weapons*. Article 36, United Kingdom. Retrieved from https://article36.org/wp-content/uploads/2019/06/directed-energy-weapons.pdf

[23] UN General Assembly. 1977. *GA Resolution 32/84-B*. United Nations. Retrieved from https://unrcpd.org/wmd/

[24] Friedman, N. 1989. *The Naval Institute Guide to World Naval Weapons Systems*. Naval Press Institute. Retrieved from https://books.google.co.id/books?id=3XKuAAAAIAAJ&redir_esc=y

[25] UN General Assembly. 1961. *Resolution 1721 (XVI) : International Cooperation In The Peaceful Uses of Outer Space.* United Nations. Retrieved from https://www.unoosa.org/pdf/gares/ARES_16_1721E.pdf

[26] UN General Assembly. 1976. *Resolution 3235 (XXIX) : Convention on Registration of Objects Launched into Outer Space*. United Nations. Retrieved from https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html

[27] UN Office for Outer Space Affairs. 2021. *UN Register of Objects Launched Into Outer Space*. United Nations. Retrieved from https://www.unoosa.org/oosa/en/spaceobjectregister/index.html

[28] Lynn, W. J. 2011. *A Military Strategy for the New Space Environment.* The Washington Quarterly, 34(3), 7-16.

[29] Saperstein, A. M. 2002. *Weaponization VS Militarization of* Space.

[30] United Nations General Assembly. 2020. *Disarmament and International Security (First Committee)*. United Nations. Retrieved from https://www.un.org/en/ga/first/

[31] Nuclear Threat Initiative. 2020. *Proposed Prevention of An Arms Race in Space (PAROS) Treaty*. NTI. Retrieved from https://www.nti.org/learn/treaties-and-regimes/proposed-prevention-arms-race-space-paros-treaty/

[32] Loc, cit.

Bibliography

Anna de Courcy Wheeler & Maya Brehm. 2017. Directed Energy Weapons. Article 36, United Kingdom. Retrieved from https://article36.org/wp-content/uploads/2019/06/directed-energy-weapons.pdf

Cornec, C. 2019. The post-Cold War issues of the space conquest: Thoughts on the future of an increasingly attractive space. University of California. Retrieved from https://escholarship.org/content/qt0kj1q52j/qt0kj1q52j.pdf?t=prfwji

Enloe, C. 2000. Maneuvers: The international politics of militarizing women's lives. Berkeley: University of California Press.

Friedman, N. 1989. The Naval Institute Guide to World Naval Weapons Systems. Naval Press Institute. Retrieved from https://books.google.co.id/books?id=3XKuAAAAIAAJ&redir_esc=y

Hebert, K. (2014). Regulation of Space Weapons: Ensuring Stability and Continued Use of Outer Space. Astropolitics, Vol. 12, No: 1, 1-26.

Lynn, W. J. 2011. A Military Strategy for the New Space Environment. The Washington Quarterly, 34(3), 7-16.

Nielsen, PE. 1994. Effects of Directed Energy Weapon. Library of Congress, USA. Retrieved from https://apps.dtic.mil/dtic/tr/fulltext/u2/a476195.pdf

Nuclear Threat Initiative. 2020. Proposed Prevention of An Arms Race in Space (PAROS) Treaty. NTI. Retrieved from https://www.nti.org/learn/treaties-and-regimes/proposed-prevention-arms-race-space-paros-treaty/

Reaching Critical Will (RCW). 2020. Outer Space : Definition and Key Issues. United Kingdom. Retrieved from https://www.reachingcriticalwill.org/resources/fact-sheets/critical-issues/5448-outerspace

Saperstein, A. M. 2002. Weaponization VS Militarization of Space.

Sproull, DC. 2017. Kinetic Energy Weapons : The Beginning of An Interagency Challenge. InterAgency Journal Vol. 8, Issue 2. Retrieved from https://thesimonscenter.org/wp-content/uploads/2017/05/IAJ-8-2-2017-pg62-68.pdf

Tanter, R. 1984. Trends in Asia. Alternatives 10, no. 1 (January 1984): 161–91. https://doi.org/10.1177/030437548401000108.

UCS Satellite Database. 2020. UCS Satellite Database. Retrieved from Union of Concerned Scientists https://www.ucsusa.org/resources/satellite-database

UN General Assembly. 1961. Resolution 1721 (XVI) : International Cooperation In The Peaceful Uses of Outer Space. United Nations. Retrieved from https://www.unoosa.org/pdf/gares/ARES_16_1721E.pdf

UN General Assembly. 1976. Resolution 3235 (XXIX) : Convention on Registration of Objects Launched into Outer Space. United Nations. Retrieved from https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html

UN General Assembly. 1977. GA Resolution 32/84-B. United Nations. Retrieved from https://unrcpd.org/wmd/

UN Office for Outer Space Affairs. 2021. UN Register of Objects Launched Into Outer Space. United Nations. Retrieved from https://www.unoosa.org/oosa/en/spaceobjectregister/index.html

UN Office for Outer Space Affairs. N.d. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. United Nations. Retrieved from https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

United Nations General Assembly. 1958. GA Resolution 1348 (XIII) : Question of The Peaceful Use of Outer Space. United Nations. Retrieved from https://www.unoosa.org/pdf/gares/ARES_13_1348E.pdf

United Nations General Assembly. 1959. GA Resolution 1472 (XIV) : International Co-operation In The Peaceful Uses of Outer Space. United Nations. Retrieved from https://www.unoosa.org/pdf/gares/ARES_14_1472E.pdf

United Nations General Assembly. 1967. GA Resolution 2222 (XXI) : Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. United Nations Office for Outer Space Affairs. Retrieved from https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html

United Nations General Assembly. 2020. Disarmament and International Security (First Committee). United Nations. Retrieved from https://www.un.org/en/ga/first/

United Nations Office for Outer Space Affairs. N.d. COPUOS History. United Nations. Retrieved from https://www.unoosa.org/oosa/en/ourwork/copuos/history.html

Wood, J. 2019. The Countries with The Most Satellites in Space. World Economic Forum. Retrieved from https://www.weforum.org/agenda/2019/03/chart-of-the-day-the-countries-with-the-most-satellites-in-space/

TOPIC 2 - Space Debris and Waste Management

Summary

In the past few decades, satellites have played an important role in space research and exploitation. However, with the increase in the usage of outer space and mankind's reliance on satellite activities, the problem posed by space debris has increased significantly. Space debris can be defined as defunct man-made objects in space. These objects, which exist at an altitude of up to 40,000km, can return to Earth and burn up during atmospheric reentry themselves. However, the remaining debris can stay in orbit for up to a thousand years.[1] A large portion of space debris is generated from high-speed collisions between two bodies in outer space, with upwards of thousands of individual smaller debris being generated from a single collision. This situation is rare but when it occurs, it generates a significant amount of harmful debris that can remain in space near indefinitely, requiring human effort to remove.

However, space debris is not only generated by collisions. A large majority of satellites launched before the advent of the 21st century were left behind in space once they became defunct, and now take up the limited space for satellite orbit around the Earth. Recently, non-state actors such as private companies have also come to play a significant role in the usage of outer space.

So far, 42,000 objects are currently being tracked in space, half of which are regularly checked by the US Space Surveillance Network (US-SSN).[2] These objects' total mass can weigh up to more than 7500 tons.[3]

Research has shown that a 40-year delay in actions taken by the international community to resolve the issue of space debris will reduce the effectiveness of such solutions by 25%.[4] While the opportunity is still present, all states have to take action

to deal with the problem as soon as possible. This is a task that requires international cooperation to succeed.

Introduction

With the advent of the 21st century and the leaps and bounds made in the development of technology, an increasing proportion of everyday life is facilitated by services derived from satellites; Global Positioning System (GPS) and 4G internet connection are some of the most essential facets of an urban lifestyle that many people lead. However, satellites that have been launched to date have little in regard to plans for their effective decommissioning. As a result, satellites that have become defunct are simply left in outer space, occupying space in Earth's orbit that has become increasingly precious as satellites continue to be launched. Worse still, the accumulation of defunct objects in space has resulted in additional generation of numerous smaller pieces of space debris through collision between two bodies orbiting Earth. This chain-reaction effect of increasing generation of space pollution is known as Kessler Syndrome. With insufficient action being taken on the problem of space debris over the past few decades, the amount of space debris has continuously grown and now poses a significant problem to the international community's activities in outer space, due to heightened risk of collision during space missions.

Obviously, the occurrence of space debris cannot only be attributed to collision; private space companies also play an important role in this issue. For instance, in 2020, SpaceX had launched 60 new satellites for their Starlink program, a program with the purpose to help people access cheap, satellite-based internet, increasing the total number of Starlink satellites to approximately 400.[5] With the advent of more private space companies, the Low Earth Orbit (LEO) has become ever more crowded.

In recent years, scientists and engineers have minimized the amount of space debris produced from newer satellite designs, but there are still tons of debris floating around the Earth. According to data from NASA, there are about 13,000 such objects that are bigger than 10cm in diameter, more than 100,000 pieces with diameters in the range between 1 cm and 10 cm and around ten thousand more of them that are of diameters smaller than 1 cm.[6]

As evidenced by those data, the amount of space debris is enormous. Not only can they cause problems for our research in space, space junk can also re-enter Earth, causing more problems down on the ground, and affecting countries regardless of their spacefaring capabilities. Therefore, all state members have a vested interest in reducing the amount of space debris.

Background

Causes and Effects

In the catalogue of the United States Space Surveillance Network (US-SSN), satellites make up about 24% of tracked objects in orbit, with an additional 18% being mission-related objects and spent upper stages.[7] The 290 in-orbit fragmentation events recorded by US-SSN since 1961 include explosions of spacecraft and upper stages, accidental collisions, and destruction due to anti-satellite weaponry.[8] In 1996, a French satellite collided with debris ejected from a French rocket exploding 10 years before.[9] In January 2007, Chinese's satellites and missile tests added 25% of space junk into orbit.[10] Furthermore, on February 10, 2009, a collision between a defunct Russian satellite and a functioning US IRC at the velocity of 11.7 km/s had created 500 new pieces of space debris.[11]

Apart from collisions, another factor contributing to the increase in the number of space junk is fragmentation events. These events have generated tons of

debris whose diameters are larger than 1 centimeter. However, a key factor of in-orbit explosions is the energy sources that reside on board. As the duration spent in space by the spacecraft progresses, the mechanical unity of both internal and external parts may be reduced, creating leaks or mixing energy components which leads to self-destruction. This not only wipes out the object itself, but also spreads out numerous fragments.

As a result, with the increase in the population of objects in space, especially in the altitude between LEO and geostationary orbit, there will be a rapid increase in the generation of space debris due to collisions between themselves as per Kessler Syndrome. Moreover, space missions have significantly higher chances of failure due to collision with space debris. Every year, hundreds of collision avoidance movements are required to mitigate the risk of such incidents. Since 1999, there have been 25 space debris avoidance maneuvers conducted by the International Space Station (ISS).[12]

Past Actions

The United Nations has considered space debris as a serious issue since 1984. However, there has been a significant lack of effort in crafting mitigation measures. In the Rescue Agreement in 1968 adopted by the General Assembly, there was a clause that required nations to return their objects in space to their owners on Earth.

One of the reasons for the failure of the treaty is the provision of very few practical benefits to nations not joining the space programme. The treaty only gives nations the right to call upon the assistance of launching authority to turn space junks into intoxicated objects.[13]

Another effort to combat the problem was the publishing of the "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space" by the

United Nations Office for Outer Space Affairs (UNOOSA). This document contains seven guidelines which demanded member States to reduce the amount of debris released during normal operations, minimize the potential of self-destruction during and post-operations, limit the number of collision cases and reduce the long-term presence of objects in the LEO and GEO region.

Surveillance

It is necessary to have regular surveillance of space junk to obtain crucial information so that we can, on both national and international levels, manage a database of space debris as completely and comprehensively as possible. This also allows nations to operate on accurate models depicting the status of man-made objects at the same time. Such an effort not only supports nations with information regarding the physical properties and the evolution of those objects but also about changes in space environment. This enables them to easily control the amount of space debris to reduce the risk made by objects near Earth's space and reduce the risk of collision between spacecraft and small-size space junk which is hard to trace. Moreover, this helps nations determine and classify the sources of those objects. From those collected results, scientists can apply it to design mitigation measures which are made to avoid generation of new debris objects in the most practical and cost-effective way.

Nowadays, the common convention to acquire information on objects with a diameter greater than 1 centimeter is to use ground-based radars and electro-optical sensors and place them on Earth and on board. These operations can be based on different methods and can be aimed at individual objects and population data. For objects that are less than 1mm in diameter, they are conventionally measured in situ via special directors. These results can be applied in estimating the physical properties of each object. With the huge amount of objects left in space, a

comprehensive study of these objects requires a lot of scientific knowledge, and financial and human capital.

Even though the development in technology makes it easy to monitor space, no country in the world is able to provide complete and frequently updated data about the problem. All states need to cooperate with each other to study man-made debris, especially since the cost for tools and technology of optical object observation to monitor all debris present is too great for a single country to bear.

Possible Solutions

With the severity of the adverse effects caused by space debris, involved parties must come up with a solution to prevent the generation of objects left in orbit as well as remove existing debris. There has resulted in two main methods to limit the amount of space debris: post-mission disposal and active debris removal.

The concert of post-mission disposal (PMD) is the reduction in the amount of unused objects being left in space. One technique here is to control re-entry of objects into Earth's atmosphere. This both eradicates unused objects in the space and lessens hazards on the ground, but it requires a great amount of energy. This technique is used for objects having a short mission time frame. In case the object's re-entry cannot be controlled, engineers sometimes utilize a limited lifetime disposal orbit, which means the object will be put in a post-mission orbit causing it to re-enter Earth. A general rule is that an object should not stay in orbit for more than a quarter of a century after its mission.

The active debris removal method (ADR) is similar to the PMD method conceptually. However, it is distinct from the PMD method in that the disposal is undertaken by an external vehicle that supplies the mechanism and that it can be applied to any objects in space. However, there are still some disadvantages of this

method. It is both expensive and limited in its scope of use, mainly targeting larger, trackable objects in space for removal due the difficulty in tracking smaller sized objects. Since the cost for this method is quite high, it is desirable if and only if it can mitigate various objects within the frame of a single mission. Hence, this can be used at GEO where a lot of used space junk is being left but its usage is less favourable in LEO. If an ADR method is used, it should have the ability to remove much of that type of debris.

To sum up, the PMD method is cheaper than the ADR method. If there were a number of space missions attached with the PMD, there would be no junk emitted into space. Meanwhile, the ADR method should be used for big objects or objects in the LEO due to its cost.

Definitions

Space debris: At first, this term was used for natural debris that was found in the solar system such as asteroids, comets and meteoroids. Now, it is also used for artificial articles. There are 2 types of debris: ground-based space debris and space-based space debris [14].

Ground-based space debris is man-made debris that gets ejected into space. These can be from very big objects like dead spacecrafts, rockets or satellites to very small particles such as pieces that have fallen from satellites or rockets during its mission.

Space-based space debris is debris that comes from outer space, produced by collisions of asteroids and planets. In addition, space-based space debris may also be comets, small asteroids, and other objects ejected into space from other collisions.

Geostationary Earth Orbit: This term is made for satellites that travel at the same rate as the Earth (approximately 24 hours). These satellites is defined to have an attitude of 35 786 km above the Earth.[15]

Low Earth Orbit: This is an orbit that is very near the earth's surface - in the range from 160 km to 1000 km. LEO is an orbit widely used because its orbit is easily changeable for different uses and purposes. Satellites in this orbit move very fast in space.[16]

Medium Earth Orbit: This term is used for any orbit that has the altitude between the LEO and GEO. It is often used for navigation satellites.[17]

Collision: The situation when a moving object strikes against another object with force. In context of this guide, this term refers to the collisions between two objects in space (e.g., between asteroids and satellites).

Debris mitigation: The action of removing harmful debris in space. These mitigations can both be classified under internal and external mitigation. According to UNCOPUOS guidelines, there are 7 guidelines that should be taken into account when planning missions and operating.

Scope of Debate

Out-of-date and out-of-commission satellites

Defunct satellites play a major role within the issue of space debris. Given the lack of action towards these satellites, their contribution towards exacerbating the problem of space debris only grows, be it through posing a collision threat, occupying precious space, or creating new space debris through collisions. Although a set of Space Debris Mitigation Guidelines has been established by UNOOSA, it is still insufficient and does not adequately resolve the problem, which requires the concerted effort of the international community, as well as private space companies. The mutual sharing of information regarding tracking of space debris through an international framework can assist stakeholders in safeguarding their space assets from unexpected collisions with space debris.

At the same time, involved parties need to take a proactive stance towards the issue. Insufficient effort in the removal of existing space debris would be akin to leaving the problem to grow until it reaches proportions where the combined efforts of the international community would still be unable to resolve. Generation of space debris from newly launched satellites should be mitigated through enabling post-mission disposal options on these satellites. Efforts should also be made towards removing existing space debris from outer space, reducing the possibilities of

collisions generating more space debris. Now-defunct satellites that were launched previously should also be disposed of through various methods.

Involvement of Non-State Actors

The core issue of the involvement of non-state actors is the significant legal ambiguities regarding the status of private companies in orbital space. Such loopholes allow the US government to circumvent its obligations to the UN Outer Space Treaty (OST), whilst simultaneously undermining the notion of space as a 'global commons' through a commodification process. The private property right over extra-terrestrial resources that lack specificity on the OST has the prospect of reinforcing Earth-bound wealth inequalities and US dominance in space, by restricting the potential economic benefits for the broader global citizenry in favor of a narrow class of wealthy American investors. Moreover, the OST's weak clause regarding the regulation of space surveillance risks the incentivisation of a 'global panoptic on' network of US satellites. Finally, the increasing number of private satellite constellations is facilitating the possibility of explosive space debris collisions which could exacerbate geopolitical tensions. Such developments are also contributing to the contamination of the broader space environment in ways that the OST had never envisioned.[18]

Collision avoidance

With the increase in the amount of space debris, collision avoidance has become one of the most essential technologies for space missions. It involves calculating the time to closest approach, the velocity of the object that is approaching and the size of that object. In general, the decision of collision avoidance must be made within 48 hours. A greater amount of space junk would significantly increase the complexity of such collision avoidance calculations, leaving greater room for error leading to catastrophic accidents.

Key Stakeholders

Satellite Operators

Satellite operators are firms or organizations that are involved in operating satellites and comprise one of the biggest stakeholders in the issue. Some of the most well-known satellite operators include SpaceX, Planet Labs, Inc. and Spire Global Inc. Satellites are used for a myriad of commercial purposes, including communications, navigation and climate monitoring. For these purposes, satellite operators are responsible for launching thousands of satellites - many of which are now defunct and are now contributing to space debris through collision cascades. In 2020, the Union of Concerned Scientists determined that out of the estimated 6,000 satellites circling the Earth, only 2,787 of them were operational.[19] As such, it may be key to hold satellite operators accountable for the space debris they generate through irresponsible management of defunct satellites, since they comprise a major portion of all space debris.

Launch Providers

Launch providers are firms which provide services in launching spacecraft, and are responsible for the various processes involved. These include assembling the carrier rocket, as well as incorporating the shipment. Launch providers are some of the biggest offenders in the issue, since carrier rockets comprise several parts ("stages").[20]

Upper stages of carrier rockets are often left behind in orbit, which proves to be a dangerous problem.[21] While rocket bodies themselves can pose a threat if a collision occurs, the greater concern is that of the leftover fuel and power supplies on the spacecraft, which may lead to explosions.[22] Propellant tank and battery

explosions can lead to creation of more debris, as well as propulsion of already-existing debris at higher velocities.[23]

While launch providers have been more responsible in following orbital debris mitigation guidelines in recent decades, it is still important to devise solutions that continue to minimize the possibility of launch vehicle-driven accidents.

Consumers (End Users)

While not directly responsible for the production of satellites and other components of space debris, end users of space-based services are key stakeholders in the issue. With the many uses of satellites listed previously, end users include all consumers who demand communication services, geopositional information, weather forecasting services, etc. [24]

It has been theorized that the inaction by satellite operators and launch providers is driven by a lack of awareness amongst end users of satellite services.[25] In common markets such as fashion, demand for sustainable, environmentally friendly clothing has in turn driven firms to look towards greener alternatives.[26] When applied to space services, consumer demand may encourage firms to adopt more responsible practices. As such, it is key to create policies that engage consumers to look towards sustainable and responsible use of space.

Governments

Governments have a stake in the issue due to their interests in space exploration for economic benefit, scientific advancement, and ensuring national security. This creates incentives for governments to involve themselves in the management of space debris.

The **United States** has been examining this problem since 1979. Under the NASA Orbital Debris Program, the United States has sought to generate a smaller volume of orbital debris, and to track and remove debris already present in orbit.[27] The U.S.'s commitment towards the issue is demonstrated through its National Space Policy of June 2010.[28] The policy directs the Department of Defense and NASA to "pursue research and development of technologies and techniques… to mitigate and remove on-orbit debris…".[29] However, the task of removing existing in-orbit debris has not been assigned to any U.S. government entity.[30]

With the second-largest number of satellites in space and rapid advancement of their space programme in recent decades, the **People's Republic of China** may take interest in the removal of space debris but has done little thus far in aiding this cause. It is likely that China will look towards technological solutions in doing so. This is demonstrated by reports of China's interest in using lasers to destroy orbital debris.[31]

The **Russian Federation**, while being scientifically advanced in development of extraterrestrial technologies has also contributed little towards the removal of space debris in previous decades. However, Russian interest in the issue has been recently renewed. Through the state corporation Roscosmos, Russia is looking towards developing space surveillance satellites to monitor space debris, as well as satellite shields to lower the danger of collisions.[32] [33]

Questions A Resolution Must Answer (QARMAs):

1. How should nations collaborate with each other to give solutions on reducing space junk?

2. How should nations act to cut down the maximum amount of space debris that can be emitted during space operations?

3. What are the common principles that can be implemented without violating individual benefits of each nation?

Endnotes

---

[1] Jonathan O'Callaghan. *"What Is Space Junk and Why Is It a Problem?"* Natural History Museum. Accessed January 31, 2021.Retrieved from https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html.

[2] *"About Space Debris."* ESA. Accessed January 31, 2021. Retrieved from https://www.esa.int/Safety_Security/Space_Debris/About_space_debris.

[3] Ibid.

[4] *"Mitigating Space Debris Generation."* ESA. Accessed January 31, 2021. https://www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation.

[5] Mohan, Ram. *"Space Exploration: Companies Breach New Frontiers - Private Participation in Space Exploration,"* June 7, 2020. Retrieved from https://economictimes.indiatimes.com/news/science/space-exploration-companies-breach-new-frontiers/scaled-composites/slideshow/76243345.cms

[6] Dunbar, Brian. *"What Is Orbital Debris?,"* June 1, 2015.Retrieved from https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orbital-debris-58.html.

[7] *"About Space Debris."* ESA. Accessed January 31, 2021. Retrieved from https://www.esa.int/Safety_Security/Space_Debris/About_space_debris

[8] Ibid.

[9] Garcia, Mark. *"Space Debris and Human Spacecraft."*NASA. NASA, April 14, 2015. Retrieved from https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

[10] Ibid.

[11] Ibid.

[12] *Rep. Technical Report on Space Debris.* New York: United Nations, 1999.

[13] G. Dembling, Paul, and Daniel M. Arons. *Rep. The Treaty on Rescue and Return of Astronauts and Space Objects.* University of Nebraska - Lincoln, College of Law, n.d.

[14] Jonathan O'Callaghan. *"What Is Space Junk and Why Is It a Problem?"* Natural History Museum. Accessed January 31, 2021. Retrieved from https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html.

[15] *"Types of Orbits."* ESA. Accessed January 31, 2021. Retrieved from https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits.

[16] Ibid.

[17] Ibid.

[18] Stockwell, S. 2020. *Legal 'Black Holes' in Outer Space: The Regulation Private Space Companies.* Ir-Info. Retrieved from https://www.e-ir.info/2020/07/20/legal-black-holes-in-outer-space-the-regulation-of-private-space-companies/#:~:text=Join%20our%20team-,Legal%20'Black%20Holes'%20in%20Outer%20Space%3A%20The,Regulation%20of%20Private%20Space%20Companies&text=Such%20loopholes%20allow%20the%20US,commons'%20through%20a%20commodification%20process

[19] *"Satellite Database | Union of Concerned Scientists."*Accessed February 7, 2021. Retrieved from https://www.ucsusa.org/resources/satellite-database

[20] *"Rocket Staging."* Accessed February 7, 2021. Retrieved from https://www.grc.nasa.gov/www/k-12/rocket/rktstage.html.

[21] SpaceNews. *"Upper Stages Top List of Most Dangerous Space Debris,"* October 13, 2020. Retrieved from https://spacenews.com/upper-stages-top-list-of-most-dangerous-space-debris/.

[22] Ibid.

[23] Ibid.

[24] TechCrunch. *"Removing Space Debris Requires Action and Caution."* Accessed February 7, 2021. Retrieved from https://social.techcrunch.com/2020/12/15/removing-space-debris-requires-action-and-caution/.

[25] Ibid.

[26] Gasparini, Allison. *"Sustainable Fashion Demand Provides New Opportunities In Material Science And Chemistry."* Forbes. Accessed February 7, 2021. Retrieved from https://www.forbes.com/sites/allisongasparini/2020/05/19/sustainable-fashion-demand-provides-new-opportunities-in-material-science-and-chemistry/.

[27] Keeter, Bill. *"Space Debris."* Text. NASA, December 5, 2018. Retrieved from http://www.nasa.gov/centers/hq/library/find/bibliographies/space_debris.

[28] *"ARES | Orbital Debris Program Office | Debris Remediation."* Accessed February 7, 2021. Retrieved from https://orbitaldebris.jsc.nasa.gov/remediation/

[29] Ibid.

[30] Ibid.

[31] . *"Cleaning Space Debris with a Space-Based Laser System."* Chinese Journal of Aeronautics 27, no. 4 (August 1, 2014): 805–11. https://doi.org/10.1016/j.cja.2014.05.002.

[32] Sheldon, John. *"Russia To Develop Space Surveillance Satellite To Monitor Space Debris As Part Of Milky Way SSA Network."* SpaceWatch.Global, June 1, 2020. Retrieved from https://spacewatch.global/2020/06/russia-to-develop-space-surveillance-satellite-to-monitor-space-debris-as-part-of-milky-way-ssa-network/

[33] sscott. *"Roscosmos Files Patent for Space Debris Satellite Shield System - Via Satellite - ."* Via Satellite, August 26, 2019. Retrieved from https://www.satellitetoday.com/government-military/2019/08/26/308438/

Bibliography

“About Space Debris.” ESA. Accessed January 31, 2021. https://www.esa.int/Safety_Security/Space_Debris/About_space_debris.

“ARES | Orbital Debris Program Office | Debris Remediation.” Accessed February 7, 2021. https://orbitaldebris.jsc.nasa.gov/remediation/.

“Cleaning Space Debris with a Space-Based Laser System.” Chinese Journal of Aeronautics 27, no. 4 (August 1, 2014): 805–11. https://doi.org/10.1016/j.cja.2014.05.002.

Dunbar, Brian. “What Is Orbital Debris?,” June 1, 2015. https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orbital-debris-58.html.

Garcia, Mark. “Space Debris and Human Spacecraft.” NASA. NASA, April 14, 2015. https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

Gasparini, Allison. “Sustainable Fashion Demand Provides New Opportunities In Material Science And Chemistry.” Forbes. Accessed February 7, 2021. https://www.forbes.com/sites/allisongasparini/2020/05/19/sustainable-fashion-demand-provides-new-opportunities-in-material-science-and-chemistry/.

G. Dembling, Paul, and Daniel M. Arons. Rep. *The Treaty on Rescue and Return of Astronauts and Space Objects*. University of Nebraska - Lincoln, College of Law, n.d.

Jonathan O'Callaghan. “What Is Space Junk and Why Is It a Problem?” Natural History Museum. Accessed January 31, 2021. https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html.

Keeter, Bill. “Space Debris.” Text. NASA, December 5, 2018. http://www.nasa.gov/centers/hq/library/find/bibliographies/space_debris.

“Mitigating Space Debris Generation.” ESA. Accessed January 31, 2021. https://www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation.

Mohan, Ram. “Space Exploration: Companies Breach New Frontiers - Private Participation in Space Exploration,” June 7, 2020. https://economictimes.indiatimes.com/news/science/space-exploration-companies-breach-new-frontiers/scaled-composites/slideshow/76243345.cms.

Rep. *Technical Report on Space Debris*. New York: United Nations, 1999.

“Rocket Staging.” Accessed February 7, 2021. https://www.grc.nasa.gov/www/k-12/rocket/rktstage.html.

“Satellite Database | Union of Concerned Scientists.” Accessed February 7, 2021. https://www.ucsusa.org/resources/satellite-database.

Sheldon, John. “Russia To Develop Space Surveillance Satellite To Monitor Space Debris As Part Of Milky Way SSA Network.” SpaceWatch.Global, June 1, 2020. https://spacewatch.global/2020/06/russia-to-develop-space-surveillance-satellite-to-monitor-space-debris-as-part-of-milky-way-ssa-network/.

SpaceNews. “Upper Stages Top List of Most Dangerous Space Debris,” October 13, 2020. https://spacenews.com/upper-stages-top-list-of-most-dangerous-space-debris/.

sscott. “Roscosmos Files Patent for Space Debris Satellite Shield System - Via Satellite -.” Via Satellite, August 26, 2019. https://www.satellitetoday.com/government-military/2019/08/26/308438/.

TechCrunch. “Removing Space Debris Requires Action and Caution.” Accessed February 7, 2021.

https://social.techcrunch.com/2020/12/15/removing-space-debris-requires-action-and-caution/.

"Types of Orbits." ESA. Accessed January 31, 2021. https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits.

Wei-Haas, Maya. "Space Junk Is a Huge Problem-and It's Only Getting Bigger." Science, April 25, 2019. https://www.nationalgeographic.com/science/space/reference/space-junk/.